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The transition towards a bio-based economy: A comparative study based on social network analysis

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ABSTRACT

This paper focuses on the development of a bioplastics innovation niche as an important sector of the bio-based economy and a viable solution to promote sustainable long-term growth. Relying on the Strategic Niche Management framework, the following niche mechanisms are analysed: (1) convergence of expectations, (2) learning processes, and (3) networking with powerful actors in the sector. We conducted a comparative analysis, looking at Italy and Germany, two frontrunner countries in the bioplastic production who have enacted divergent policies in support of this sector. The comparative perspective has brought some interesting insights into the maturity level of the two respective niches, as well as into the emerging architectural properties of the underlying social networks. Core findings show a general high level of expectations in the bioplastics sector in both countries, whereas key elements undermining the niche development refer either to the lack of policy support or to the changing and unstable institutional and regulatory framework. Regarding the architectural structure, the Italian network of actors was largely characterized by an active exchange of knowledge among firms, whereas the German network was characterized by the presence of several institutional actors actively participating in knowledge flows. This last result relates, in the authors' view, to the different policy strategies followed by national governments in the two countries: the German case being characterized by large public investment in R&D, whereas the Italian case is mostly characterized by demand side policies that effectively created a market for bioplastic shoppers.

1. Introduction

Coupled with current mass production and consumption models, the global population growth is putting the availability of global resources needed to fuel long-term growth under pressure. As pointed out by several scholars, current socio-economic challenges demand a radical change in consumption habits (Spaargaren, 2011; Seyfang, 2009) and in the production system (Maxwell and van der Vorst, 2003) through the development of innovative and sustainable technologies. New technologies could indeed facilitate the transition from a society based on fossil fuel resources, mass consumption and inefficient waste management, to one based on renewable resources and biomass, reduced consumption and reuse-oriented waste management (Morone, 2016). Against this background, the bio-based economy has gained momentum in the transition literature as one of the primary paths through which this 'change of perspective' will occur (see e.g., Hermans, 2018; Røste et al., 2017).

In this paper we focus particularly on bioplastics that represent "the fastest growing bio-based product line globally" (Iles and Martin, 2013: 39). Above all, the future evolution of this key sector of the broader bio-based economy is of great importance for European countries, due to two fundamental, and substantially "quantitative", reasons: on the one hand, the consumption of plastics in Europe is considerable, equalling 58 million tonnes annually (PlasticsEurope, 2016); on the other hand, food waste in the EU has reached around 88 million tonnes annually (Stenmarck et al., 2016), this representing a sizeable amount of potential feedstock to be used in the production of bio-based products, including bioplastics (Bayer et al., 2014; Fava et al., 2015; Oldfield et al., 2016; Ladu and Quitzow, 2017; Imbert, 2017; Rodriguez-Perez et al., 2018; Strazzera et al., 2018). To date, research has mainly focused on the technical aspects of bioplastics production, however, there are hardly any studies focusing on pathways of evolution from technological research and innovation to technological bioplastics niches maturation in European countries. Bearing this in mind, and building

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on Morone et al. (2015), this paper provides an assessment of the journey towards maturity of the bioplastics niches in Italy and Germany. Specifically, relying on the Strategic Niche Management framework, the following niche mechanisms are analysed: (1) convergence of expectations of the firms involved in bioplastics production in Italy and Germany, (2) their learning processes through exchange of informal and formal knowledge, and (3) their networking activities with powerful actors involved in the bioplastics sector.

The comparative nature of this assessment provides some interesting insights as Italy and Germany represent two interesting case studies due, on the one hand, to their strong consumption of conventional plastics, and on the other hand, to their high bioplastics production capacity. This is all the more interesting considering that Germany and Italy have implemented divergent policies in support of the bioplastics industry over the last few years (Imbert et al., 2017). Hence, results obtained on the emerging architectural properties of the two niches will be linked, in a retrospective way, to the different policy strategies enacted by the respective national governments, under the common umbrella of the EC policy for the bio-based economy (see Bell et al., 2018). Therefore, the comparative analysis between Italy and Germany will be based on, (1) the assessment of the maturity level of the bioplastics niches, and (2) their connection with national policies in support of the bio-based economy. In order to accomplish the goals of this paper, a combination of qualitative and quantitative tools, including experts' opinion and Social Network Analysis, are applied. In what follows we will first present material and methods applied, then results will be discussed and finally conclusions will be drawn.

2. Materials and methods

Bioplastics represents a promising niche market, although it faces many challenges related to the dominant position of the incumbent fossil-based regime which can benefit from economies of scale and scope, past learning effect and coevolution of technologies and institutions (Brockhaus et al., 2016; Iles and Martin, 2013; Unruh, 2000). Nonetheless, bioplastics, especially those based on waste feedstocks, benefit from a circular economy model, where actors at all levels are engaged in collaborative networking activities and oftentimes freely share knowledge, hence generating knowledge and learning externalities (EC, 2017b; Hagemann et al., 2016). Indeed, synergies arising between institutions, research bodies, industry and consumers, define the internal forces and the external sources of pressure capable of destabilizing the incumbent socio-technical regime (Geels, 2002). Moving along these lines of reasoning, we analyse the level of maturity and the structure of the network of the bioplastics niche in Italy and Germany, relying on the Strategic Niche Management framework (Kemp et al., 1998). According to this theoretical approach, the maturity of a technological niche is grounded on three crucial mechanisms; (i) convergence of expectations towards a common view on the success of radical (and/or incremental) innovations within technological niches for challenging the incumbent regime; (ii) learning processes as a crucial means of increasing formal and informal knowledge, boosting technology transfer, and spreading the use of innovative technologies; (iii) networking with powerful actors who have resources to promote markets and infrastructures for new technologies.¹ All this comes down to the belief that “[N]o single actor has sufficient resources on their own to coordinate responses to selection pressures, or build adaptive capacity” (Smith et al., 2005: 1504). The presence or absence of these three mechanisms determines not only the emergence of an innovative niche, but also its level of maturity (empowerment) able to break through the incumbent socio-technical regime.

In this framework, different policy initiatives do play a fundamental

role in promoting one or all the niche mechanisms' development. Specifically, institutional change and policy intervention are indeed key guiding forces towards the accomplishment of the decarbonisation process, which competes with traditional infrastructures and less expensive products – typically better known by the market (Hopkins and Lazonick, 2012). For this reason, the outcome of a transition towards the bio-based economy is very much determined by the type of policy strategy implemented and the way in which it takes form. In this respect, the framework in Quitzow (2015) provides a list of criteria for the identification of different types of policy strategies, grounded on policy objectives and associated measures (*strategy content*), policy development, implementation and adaptation (*strategy process*) and institutional capacities (*strategic capacity*). Building on Quitzow (2015), Imbert et al. (2017) identified two types of policy strategies in a comparative case study, assessing the emerging bio-based economy in Germany and Italy. They pinpointed a bottom-up strategy in Italy, also defined as a demand-side policy, implemented with the law n. 28/2012, which was the result of pressure applied mostly by the private sector. On the other hand, a top-down strategy emerged in the German case, where the policy strategy was implemented by means of considerable public investment in R&D aimed at boosting research and innovation activity, and stimulating, through a supply-side policy, the emerging bio-based German economy. This analysis sets the theoretical ground for analysing how these two alternative policy tools have differently affected the emergence and development of the bioplastics niche in the two countries under scrutiny.

To compare the German and Italian bioplastics niches, while having in mind convergence of expectations, learning processes and networking activities with powerful actors in the sector, we carried out an investigation by means of both qualitative and quantitative methods, articulated into three main steps.

We started with a stakeholder analysis, reviewing academic and grey literature to identify the most relevant actors involved in both the Italian and German bioplastics industry. These included firms, research institutes/universities, public institutions, business support organizations, NGOs, and trade organizations.

As a second step, we developed a questionnaire for the firms involved in the production of bioplastics in Italy and Germany, which was composed of three sections. The first section was aimed at collecting general information about the firms involved in the bioplastics industry, with questions on their product specialization and the number of workers hired. By using a five-point Likert scale, the second part of the questionnaire was designed to gather data on firms' expectations on the future development of the bioplastics sector by focusing on current and future technologies and their environmental and economic sustainability. In addition, respondents were asked to indicate the main challenges associated with the production of bioplastics. Three questions relating to patents, trademarks and R&D funding were also included. Lastly, the third part of the questionnaire collected data on two types of firms' networks: informal knowledge sharing, and formal knowledge exchange. Together with sociometrical data, eight questions investigated the presence of powerful actors in the networks.

In the third step of our analysis, we coordinated two focus groups of stakeholders (identified in the first step) that assessed the content validity of the questionnaire; this provided a list of the five most relevant firms actually involved in the respective domestic markets. Focus groups were conducted respectively in Italian and German and were both composed of four members: a government representative, a research institution representative, an industry representative, and a trade organization representative. Each focus group was facilitated by an author of the paper.

As previously mentioned, the final part of the questionnaire specifically targeted the networks analysis since the acquisition of informal and formal knowledge through networks of relationships and the presence of powerful actors are key elements of this investigation (see Imbert et al., 2017; Giuliani and Bell, 2005). The aim of the social

¹ For a detailed description of these three niche mechanisms see Lopolito et al., 2011.

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